(12) UK Patent Application (19) GB (11) 2 139 762 A

(43) Application published 14 Nov 1984

(21) Application No 8408889

(22) Date of filing 6 Apr 1984

(30) Priority data

(31) 483230 (32) 8 Apr 1983 (33) US

(71) Applicant
Gavilan Computer Corporation (USA-California),
240 Hacienda Avenue, Cambell, California 95008, United States of America

(72) Inventors
Gary John Prosenko,
Richard Tabor,
Richard Bruce Ravel

(74) Agent and/or Address for Service
Forrester, Ketley & Co.,
Forrester House, 52 Bounds Green Road, London N11 2EY

(51) INT CL^3
G06F 3/033

(52) Domestic classification
G1N 1A1 1A3B 1D8 3S10 3S1B 4A 7E2 7F 7N 7S AQA
U1S 2125 2285 G1N

(56) Documents cited
None

(58) Field of search
G1N
H4T

(54) An input device and a method of inputting data to a computer system

(57) An input device for a computer system comprises a touch sensitive surface or pad 21 for providing signals representative of the position of a user's finger. Movement of a cursor on a display screen of a computer system is controlled in response to a user's finger moving over a defined cursor control area 63 of the surface, e.g. so that it is displaced by an amount related to the displacement of the finger and to finger speed. Once the cursor has been correctly positioned a short tap on the area 63 generates an execution signal to instruct the computer to carry out the instructions determined by the prior cursor movement. The touch-sensitive surface also has a plurality of discrete areas 65,67,69,71,73,75,77,79 adjacent the cursor control area which act as two position switches and generate control signals of the type for which discrete push button switches are generally employed.

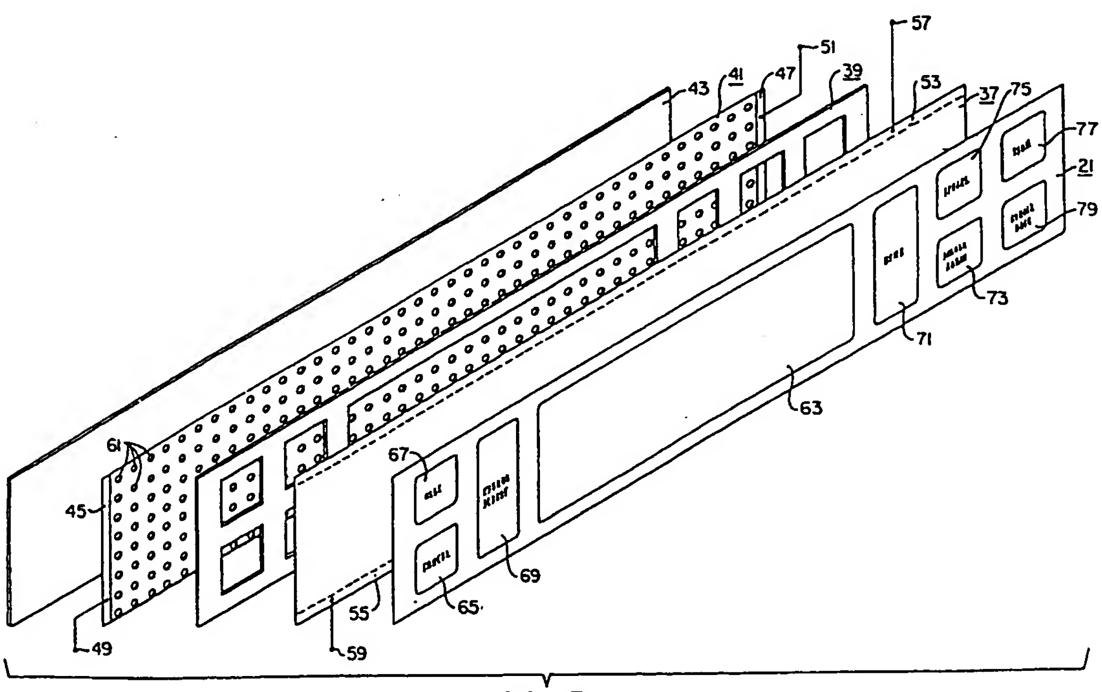

FIG. 3.

GB 2 139 762 A

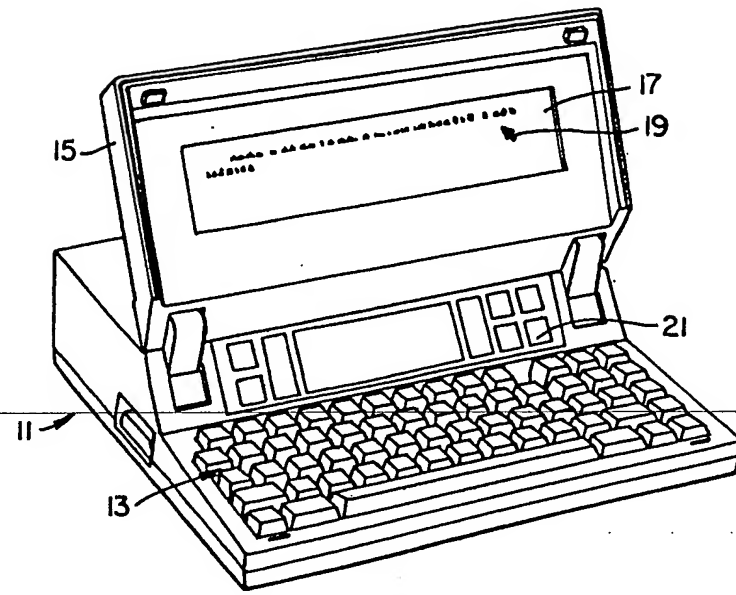

FIG. 1.

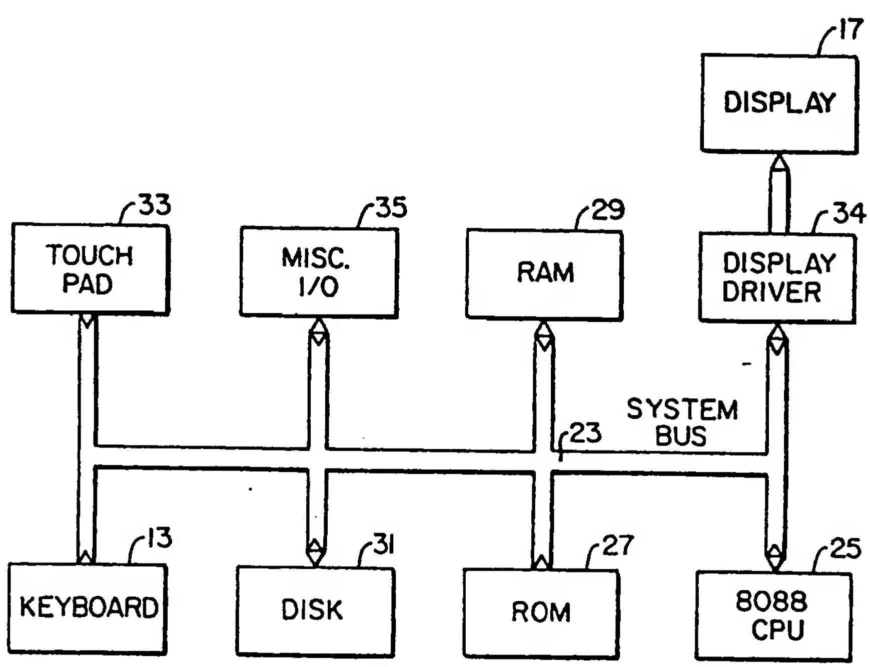

FIG. 2.

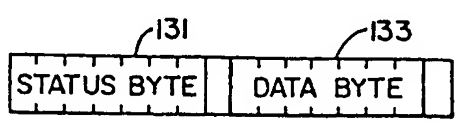

FIG. 7.

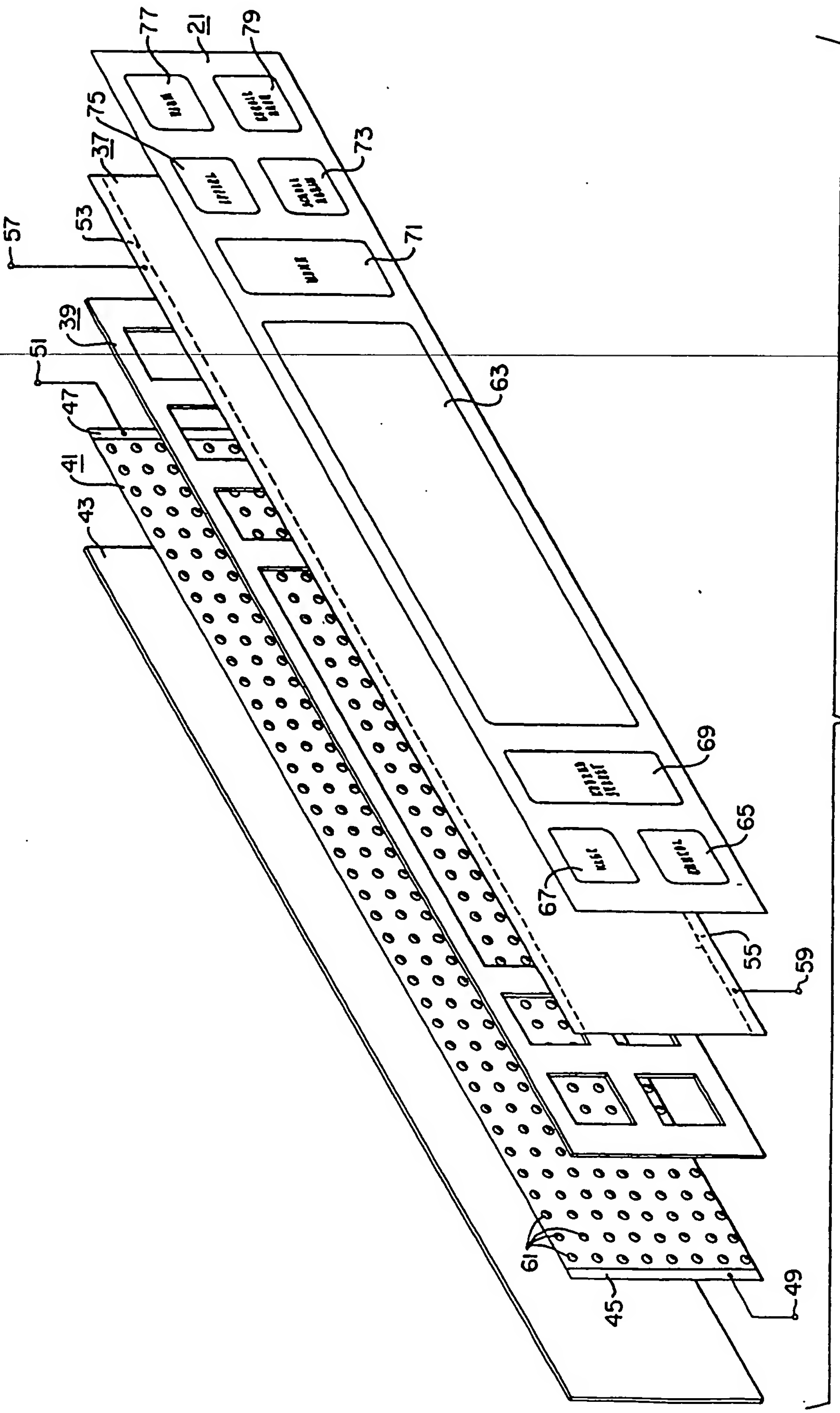

FIG. 3.

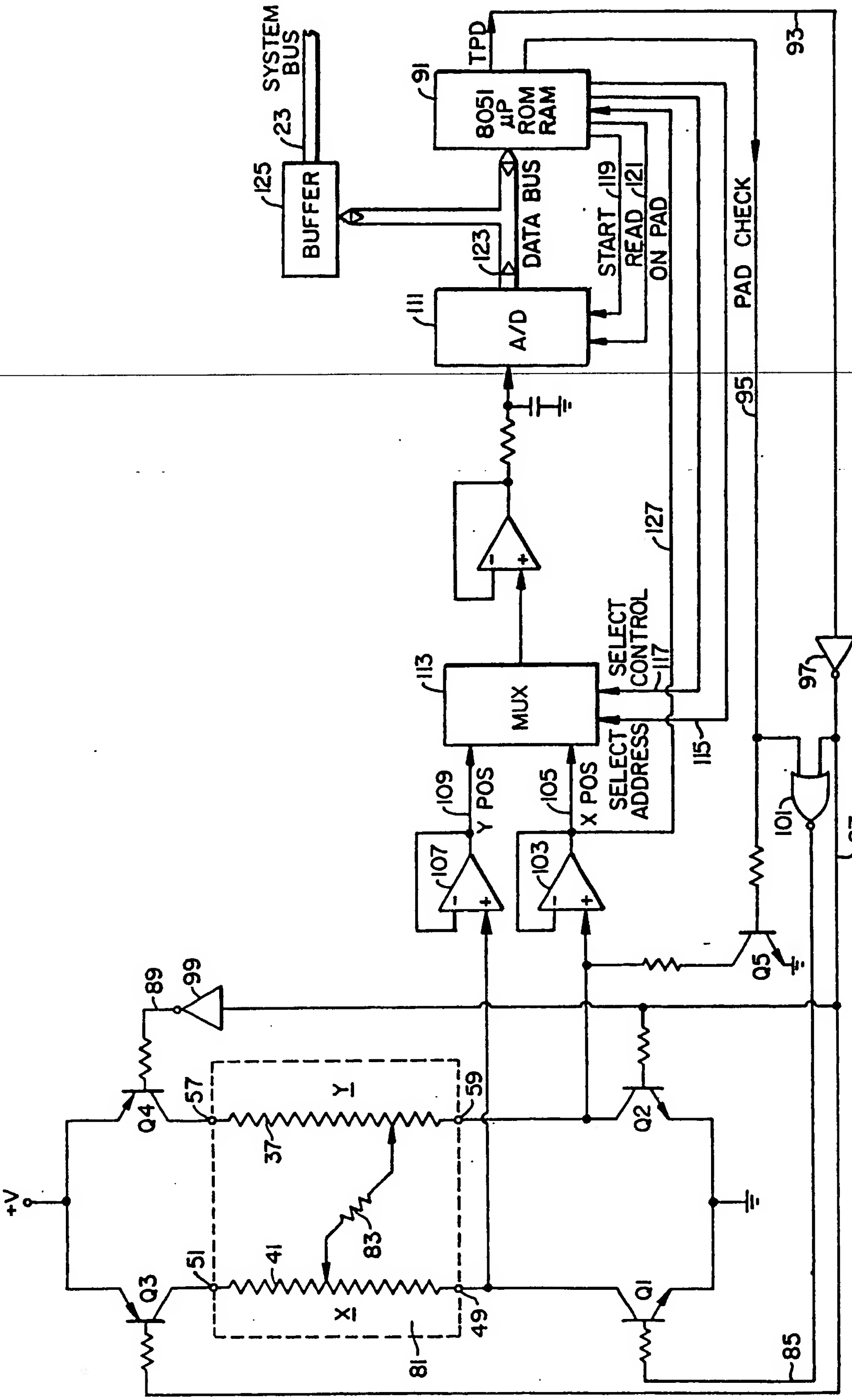
SYSTEM BUS
23
125
BUFFER
91
8051
μP
ROM
RAM
TPD
93
111
A/D
123
DATA BUS
START
119
READ
121
ON PAD
PAD CHECK
95
127
113
MUX
SELECT
CONTROL
117
SELECT
ADDRESS
115
109
Y POS
105
X POS
107
103
97
101
87
89
99
Q5
Q4
57
Y
59
37
Q2
+V
83
51
41
X
49
Q3
Q1
81
85

FIG. 4.

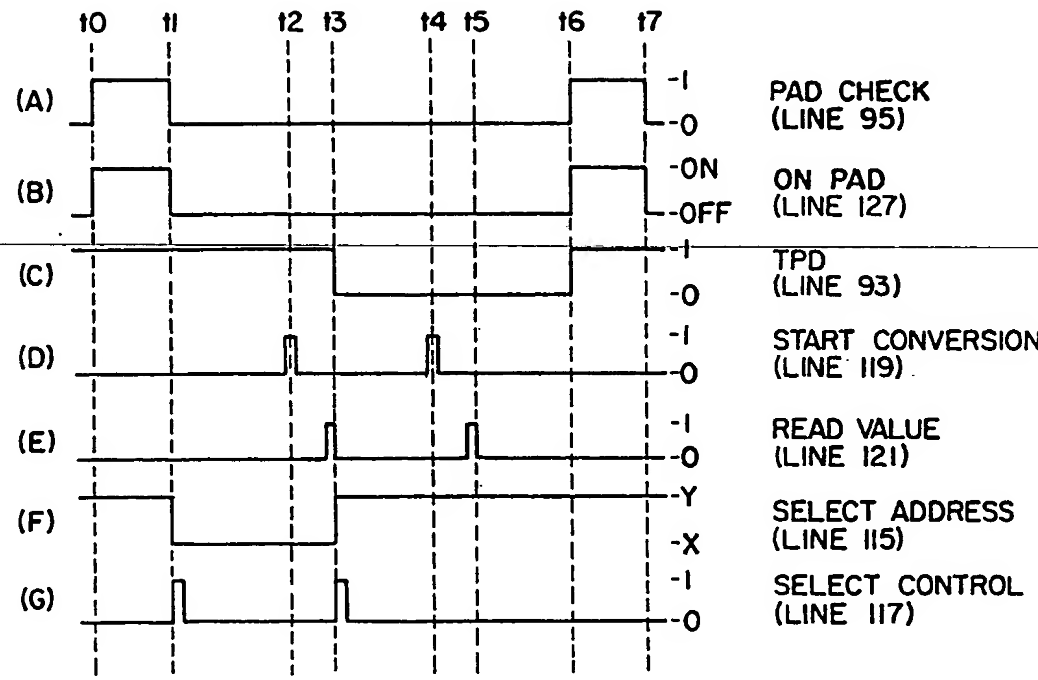
t0
t1
t2
t3
t4
t5
t6
t7
(A)
(B)
(C)
(D)
(E)
(F)
(G)
-1
-0
-ON
-OFF
-1
-0
-1
-0
-1
-0
-Y
-X
-1
-0
PAD CHECK (LINE 95)
ON PAD (LINE 127)
TPD (LINE 93)
START CONVERSION (LINE 119)
READ VALUE (LINE 121)
SELECT ADDRESS (LINE 115)
SELECT CONTROL (LINE 117)

FIG. 5.

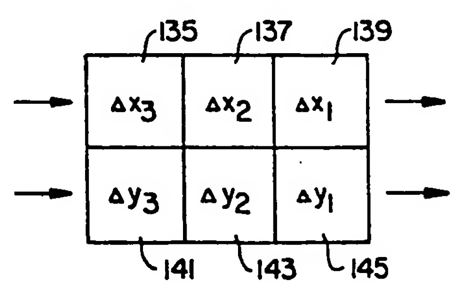
135
137
139
Δx3
Δx2
Δx1
Δy3
Δy2
Δy1
141
143
145

FIG. 6.

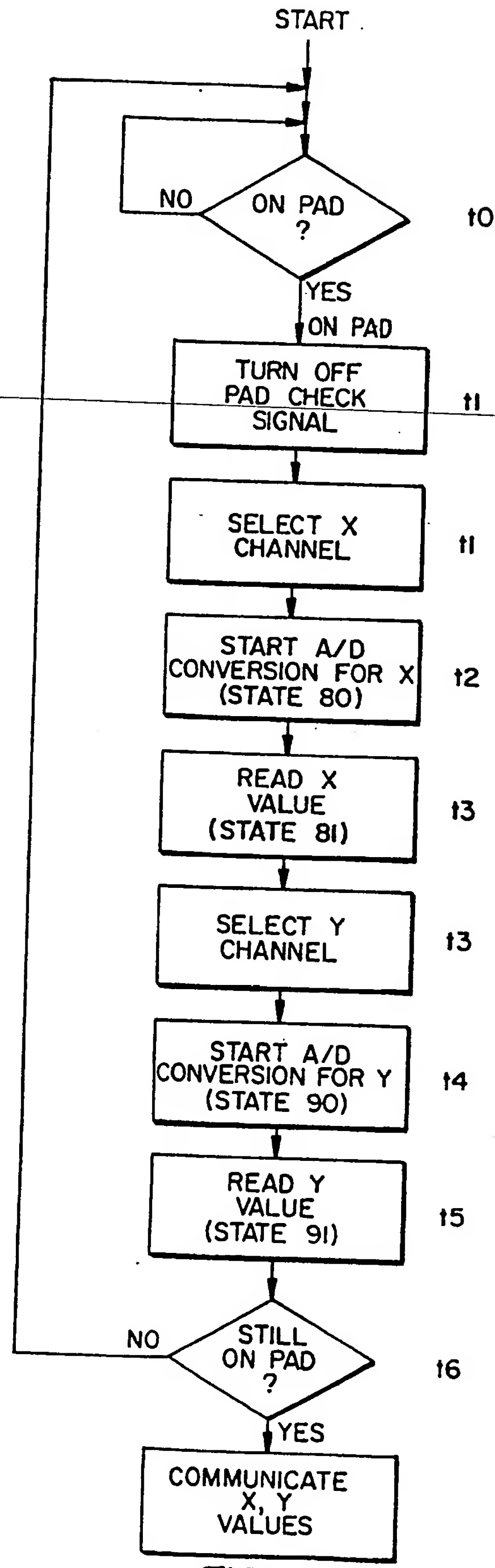
START
ON PAD ?
NO
t0
YES
ON PAD
TURN OFF PAD CHECK SIGNAL
t1
SELECT X CHANNEL
t1
START A/D CONVERSION FOR X (STATE 80)
t2
READ X VALUE (STATE 81)
t3
SELECT Y CHANNEL
t3
START A/D CONVERSION FOR Y (STATE 90)
t4
READ Y VALUE (STATE 91)
t5
STILL ON PAD ?
NO
t6
YES
COMMUNICATE X, Y VALUES

FIG. 8.

2139762

6/6

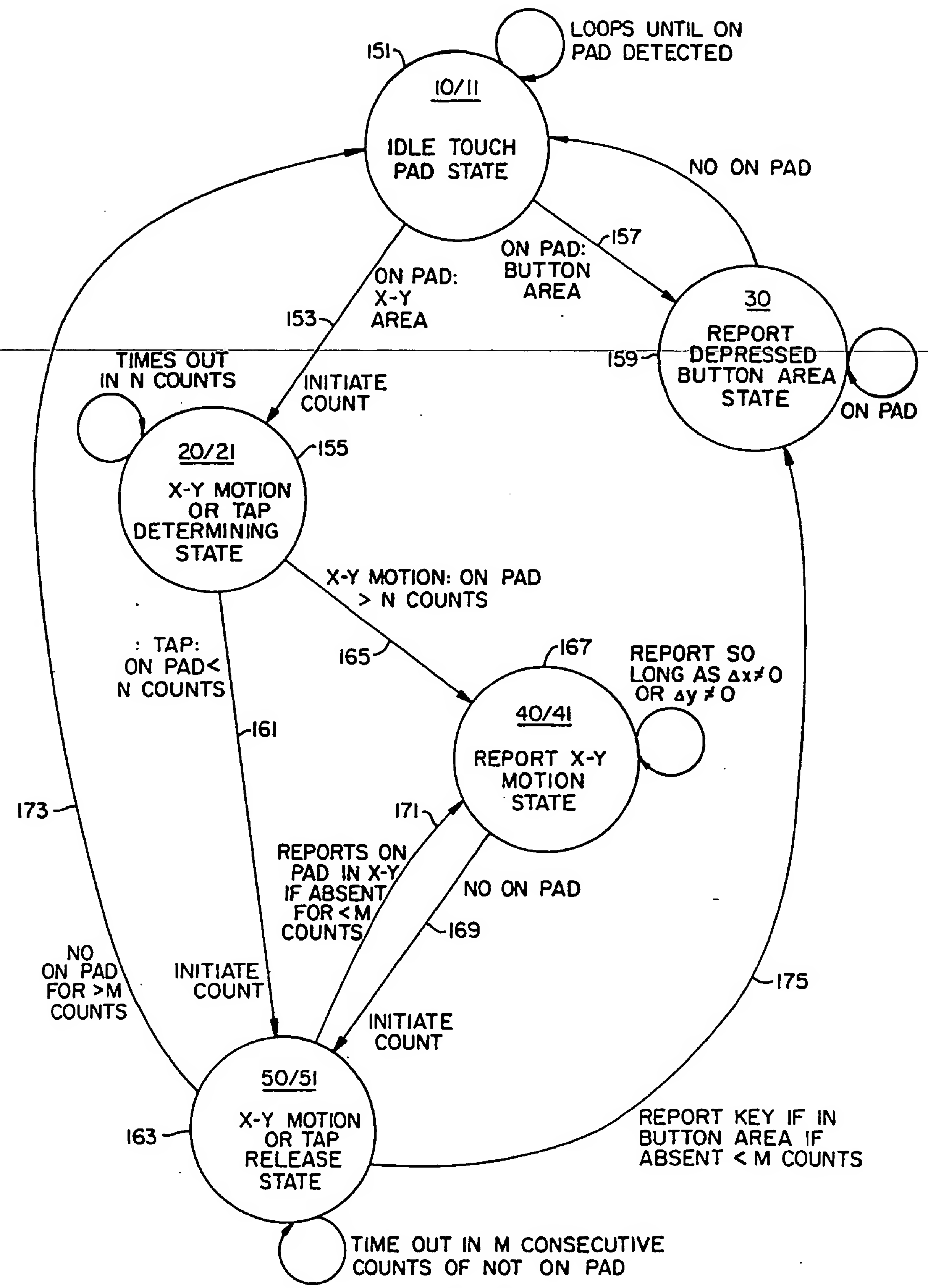

FIG. 9.

SPECIFICATION

An input device and a method of inputting data to a computer

This invention relates to an input device and a method of inputting data to a computer.

Most computer systems use a display employing a cursor, a marking device that is displayed on a screen of the display and is movable by the operator across that screen. A cursor is most commonly used to point to a location on the display where the operator desires to effect some operation. For example, a computer system operating as a word processor can replace or delete a word or letter which the cursor overlays or points to. The operator first moves the cursor to the desired location on the display and then subsequently gives a command to execute some operation at that location.

There are a number of commonly used devices and techniques for inputting these commands from the user to the computer system. An ordinary keyboard is the most common, at least in word processing applications. A mouse is becoming increasingly popular, a hand held device that is moved over a flat surface adjacent the computer system to cause the cursor to move a distance and direction proportional to the movement of the mouse. A mouse device generally also has one or more buttons on it for communicating commands to be executed by the computer system, so that a user can designate that a predetermined action be taken at the location on the display where the cursor has been positioned by the mouse.

Touch sensitive display screens are also used to generate control and data signals for input to a computer system. Other external devices include joysticks, paddle wheels, track balls and the like. These devices are often used to play games with the computer by controlling motion of a "cursor" in the form of a tank, munchkin or the like. A firing button is generally also provided with the controller for causing execution of a predetermined action once the "cursor" has been positioned where the player wants it to be.

Another cursor controlling device that is becoming accepted is a two dimensional touch pad which is provided either as part of a computer system adjacent its keyboard or as a separate device used along side it and interconnected with the system. Such a pad is sensitive to the touch and is connected to the computer system to cause its cursor to move in both X and Y directions corresponding to the movement of the operator's finger across the surface of the pad. Typical pads operate by having an electrically conductive surface with a given resistance per unit length across it. The value of resistance communicated to the computer system depends on the location of a touch on the surface by the user. Other pads operate on a magneto-strictive principle in developing a proportional to the location of touch across the pad. The touch pads now in use provide the desired cursor movement which must then be followed by some other action of the user, such as pressing a separate key, to cause execution of a function at the new cursor location on the display screen.

It is an object of the present invention to provide a input device and method of inputting data to a computer system which is easier to use, simpler in construction and yet has improved operating features.

According to one aspect of the present invention, there is provided an input device for a computer system, comprising: a touch-sensitive surface for producing a signal when the surface is touched to identify the location on the surface which has been touched; means for receiving a touch location signal for generating an area signal representing a given area of the sensitive surface when the given area is touched so that, in use, the given area acts as a two-position switch for supplying instructions to the computer system; means for receiving a touch location signal for generating a position signal representative of a change in the location on the surface being touched when that location is in another area of the surface for controlling movement of an element displayed on a display means of the computer system.

In a second aspect, the present invention provides an input device for a computer, comprising: a touch sensitive surface for producing a signal when the surface is touched to identify the location on the surface which has been touched; means for receiving a touch location signal for generating a position signal representative of a change in the location on the surface being touched when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time; and means for receiving a touch locaton signal for generating a different signal to supply instructions to the computer system when the surface is touched for a time less than the predetermined time and/or the location touched changes by a distance less than the predetermined distance.

The present invention also provides a computer system whenever incorporating an input device in accordance with the first or second aspect.

In another aspect, the present invention provides a method of inputting data to a computer system, comprising: producing a signal when a touch-sensitive surface is touched identifying the location on the surface which has been touched; generating an area signal representing a given area of the touch-sensitive surface when the given area is touched so that the given area acts as a two-position switch for supplying instructions to the computer system and for generating a position signal representative of a change in the location on the surface being touched when that location is on another area of the surface to control movement of an element displayed on a display means of the computer system.

In a further aspect, the present invention provides a method of inputting data to a computer system, comprising: producing a signal when a touch-sensitive surface is touched identifying the location on the surface which has been touched; generating a

position signal representative of a change in the location being touched when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time; and generating a different signal to supply instructions to the computer system when the surface is touched for a time less than the predetermined time and/or the location touched changes by a distance less than the predetermined distance.

In a preferred arrangement, the input device has a two dimensional cursor controlling touch-sensitive surface or pad which serves two functions. By a user moving a finger across the touch pad surface, normal cursor movement is caused on a display means of the computer system but, when the cursor is at the desired display location, the operator need not search for some other input device such as a separate key to cause execution of a predetermined function at that location of the display. Rather, the operator need only tap the touch pad quickly such a tap being discriminated by the touch pad as a different command than a longer touch which typically accompanies movement of a finger across the pad to cause the cursor to move. This allows the operator to keep his or her eyes on the display means without having to look for a separate execution button, and further allows a simpler system by eliminating the need for a separate execution button.

In the preferred arrangement the signals from the touch pad are processed before being used to move the cursor such that erratic movement of the user's finger across the touch pad is translated into a smoother movement of the cursor across the display, and the distance of cursor movement for a given distance of finger movement across the pad is made dependent upon the speed of the finger movement. The smoothing is accomplished, according to a preferred implementation, by reporting from the touch pad to the computer system incremental X and Y finger displacement per unit time with an average of a plurality of successive incremental distance movement being used to move the cursor, thereby to smooth its motion. The scaling feature is provided, according to a preferred implementation, by squaring the average incremental distance movement signals before using them to move the cursor, thereby causing the cursor to move farther for a given finger movement across the pad when the speed of such finger movement is higher.

Also in the preferred arrangement, the touch-sensitive surface comprises a plurality of given areas which provide a number of discrete switch or push button functions, the actuation of any of a number of such buttons being communicated from the touch pad on the same signal line as the cursor movement signals and execution tap signals. The discrete push button signals are separated from the X-Y signals in the common touch pad output circuit by subsequent processing. In a preferred implementation, a single touch pad is provided with spacially separated areas for a plurality of push buttons and an X-Y area. The significance of any touch by a user on the touch pad is determined from the location of that touch as expressed in the common output signal of the touch pad. In one specific form of such an implementation, two resistive sheets are normally held closely spaced and electrically connected to detect the location of a user's touch when it causes the sheets to contact at a particular location.

For a better understanding of the present invention, and to show how the same may be put into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 illustrates generally a portable computer system having an input device embodying the present invention;

Figure 2 is a general block diagram of the computer system of Figure 1;

Figure 3 shows an exploded view of a touch-sensitive surface pad of an input device embodying the invention;

Figure 4 is an electronic circuit diagram of an input device embodying the invention and having the touch pad of Figure 3;

Figure 5 is a timing diagram for the electronic circuit of Figure 4;

Figure 6 illustrates the manipulation of digital data by the circuit of Figure 4;

Figure 7 shows the format of particular digital signals of the circuit of Figure 4;

Figure 8 is a flow diagram showing the operation of the circuit of Figure 4; and

Figure 9 is a state diagram illustrating the operation of computer software provided in conjunction with the circuit of Figure 4 for processing information obtained from the touch pad.

Referring now to the drawings, in particular Figure 1, there is shown a portable computer having an input device embodying the invention. Although an input device embodying the present invention is highly useful in any computer system, it is particularly advantageous in a portable computer because of the reduced number of circuit elements that are required to perform a given set of desired functions.

As shown in Figure 1, a case 11 of the portable computer contains a keyboard 13 along a front edge that is enclosed by a cover 15 when the unit is being transported. As shown in Figure 1, the cover 15 is in an upright position and contains a display means in the form of a display screen 17 of an appropriate type. The type of screen 17 that is utilised in such a portable computer is a liquid display (LCD) because of its low power consumption. Typically, the display will be of a pixel type and be capable of displaying a plurality, such as eight or more, lines of alphanumeric information, or graphics of a similar size.

The system is capable of displaying a cursor 19, shown in Figure 1 to be an arrow. Of course, other cursor configurations can be utilised, such as a small rectangle, a large square or rectangular box enclosing a significant portion of the screen, and other various shapes and sizes depending upon the application. In any event, the cursor is movable under control of the operator over the surface of the display screen 17.

Immediately adjacent the keyboard 13 is a graphics sheet 21 which covers the mechanical part of the input device, in particular the touch-sensitive

surface or touch pad thereof. The mechanical aspects of a specific touch pad will be described below with respect to Figure 3. The orientation of the touch pad immediately adjacent the upper edge of the keyboard 13, and at a greater slope, makes it very easy for user view and access and also provides a compact assembly which is necessary for portability.

Referring to Figure 2, a general system block diagram of the computer 11 is illustrated. A common system bus 23, typical of such systems, interconnects a microprocessor 25 with the other major operating elements of the system, including a read only memory (ROM) 27, a random access memory (RAM) 29, a disk drive 31, and a display driving circuit 34. Additionally, the keyboard 13 is connected through an appropriate electronic system to the system bus and a touch pad system 33 is similarily connected in this particular system. The touch pad system 33 of Figure 2 includes the mechanical touch pad assembly illustrated in Figure 3 and its electrical circuit illustrated in Figure 4. In addition, miscellaneous input/output circuits and devices 35 are connected to the system bus, such as a printer, telephone modem, and similar commonly used peripheral devices. In the particular system being explained as an example, the microprocessor 25 is on Intel 8088.

A particular touch pad mechanical assembly will now be described with respect to Figure 3. A resistive type of touch pad is being shown but, of course, similar signals can be obtained in response to touches on a surface using other transducing mechanisms, such a magneto-strictive device that operates by measuring the time for a pulse to travel across the surface as an indication of location of the touch, and the like. Behind the cover sheet 21 is a first resistive sheet 37, followed by a spacer 39, a second resistive sheet 41, and a rigid substrate backing element 43. Each of the resistive sheets 37 and 41 is characterised by its surface facing the other having an electrical conductivity with a uniform resistivity per unit distance across the surface.

The sheets 37 and 41 can be of a number of specific alternative constructions, each of which provide equivalent electrical characteristics. They can be, for example, polyester sheet material coated on their surfaces facing each other with carbon ink or with a material vapour deposited thereon such as indium tin oxide. Alternatively, they can be elastomeric conductive sheets having electrically conductive materials, such as carbon, impregnated in the sheet itself. In any event, the resistivity per unit length is carefully controlled to uniform across each sheet and its value is chosen by the requirements of the particular electrical circuit in which the touch pad is operating.

One of the sheets 37 and 41 has an electrical potential impressed across opposite sides in the X direction, and the other in the Y direction. Metallic or other high electrical conductivity strips 45 and 47 are placed across the resistive surface at opposite edges to cause a voltage impressed at terminals 49 and 51 to be across the X direction of the sheet 41. Similarly, conductive strips 53 and 55 are placed along opposite edges of the sheet 37, thereby causing a potential gradient thereacross in the Y direction when a voltage is impressed across terminals 57 and 59.

In order to assure that the conductive surfaces of the sheets 37 and 41 do not inadvertently touch each other, a grid of dielectric bumps 61 is silkscreened onto one of them, shown in Figure 3 to be the sheet 41. These bumps are placed about 0.2 inch (5.08 mm) apart in a symmetrical pattern across the sheet 41, with a height of less than 1 mil (25.4 mm) and a diameter of about 4 mil (101.6 mm). This spacing and size allows the opposing electrically conductive surfaces of the sheets 37 and 41 to contact each other by a touch of a finger of a desired force anywhere across the sheet 37 through the thin, flexible indicia sheet 21. The sheet 37 is, of course, itself flexible to permit such physical motion and contact.

The touch pad assembly of Figure 3 is utilised to generate a number of independent signals through connection with the single common set of four terminals 49, 51, 57 and 59. The two dimensional area of the touch pad is spatially divided into discreet regions, such as an X-Y two dimensional cursor control area 63, and a plurality of discreet button areas 65, 67, 69, 71, 73, 75, 77 and 79. A larger or smaller number of discreet areas may be provided, depending upon the computer system application and the available size of the touch pad surface. As explained below with respect to Figure 4, the particular one of these areas that is depressed is identified by determining the X-Y coordinates of a contact between the resistive surfaces of the sheets 37 and 41.

In order to aid in this discrimination, a thin non-conductive spacer sheet 39 is positioned between the electrically resistive sheets 37 and 41. Apertures are provided in the sheet 39 in the same pattern as the indicia on the surface of the sheet 21 for the different button and X-Y cursor control areas. The spacer 39 is not absolutely necessary but does make it easier to discriminate the different discreet areas by the electronic system to be described.

Referring to Figure 4, an electrical schematic diagram is shown wherein the touch pad of Figure 3 is represented electronically by the resistances within dotted outline 81. A resistance 83 represents the contact resistance as the sheets 37 and 41 are pushed together at a particular point by the touch of a computer user. The location of such contact is schematically shown in Figure 4 by an electrical connection at particular locations of the resistor of the sheet 41 in the X direction and the resistor of the sheet 37 in the Y direction. The location of the connection between these two representative resistances of the surfaces 37 and 41 will vary in both the X and the Y direction as the location of the touch across the two dimensional surface of the touch pad is changed.

A power supply voltage +V is selectively impressed across the resistance sheet surfaces 37 and 41 under the control of four transistors Q1, Q2, Q3 and Q4. These transistors operate as switches. Transistor Q1 is connected between terminal 49 and ground potential and is maintained in a conductive or

non-conductive state depending upon the voltage level in a conductor 85 which is connected through a resistance to the base terminal of transistor Q1. Similarly, transistor Q2 is connected between terminal 59 and ground potential with its base connected through a resistance to a control line 87. Transistor Q3 is connected between the positive voltage supply +V and the terminal 51, its base being connected through a resistance to a the line 87. Transistor Q4 is connected between the positive voltage supply +V and the terminal 57, its base being connected to a line 89 through a series resistance.

The control signals to turn these four transistors on and off originate from a central processing unit (CPU) 91 in the form of a TPD control signal in an output line 93 and an PAD CHECK signal in a line 95. For the particular system being described, the CPU 91 is preferably an Intel 8051 microprocessor which includes a certain amount of ROM and RAM. A bi-level control signal in line 93 is passed through an inverter 97 whose output provides a control signal in line 87. The Control signal in line 87 is similarly passed through an inverter 99 which provides a control signal in the line 89. The inverters 97, 99 are preferably made of CMOS integrated circuit elements. Transistors Q3 and Q4 are of the PNP type and the transistors Q1 and Q2 are of the NPN type. The PAD CHECK bi-level signal in line 95 is applied to one input of a NOR gate 101 and to the base, through a series resistance, of an NPN transistor Q5. A second input to the NOR gate 101 is the line 87. The transistor Q5 is effectively connected between the terminal 59 and ground potential, through a series resistance, and is controlled in its on and off states by the signal in the line 95. An output of the NOR gate 101 provides a control signal in line 85.

As will be explained more fully below, the X and Y coordinates of a touch on the sheets 37 and 41 are determined in separate time sequential steps. In one instance of time, the transistors Q1 and Q3 are turned on to impress a voltage across the X resistance 41 while the Y axis resistance 37 acts as a pick-off to communicate the voltage at the location on the resistive sheet 41 where the touch has occured. It is communicated through terminal 59 which is connected to a non-inverting input of an operational amplifier 103 whose output 105 is connected directly to its inverting input. The amplifier 103 acts as a buffer so that the Y axis resistance 37 is not itself loaded down, otherwise it could not serve to read the voltage at the point of its connection with the X axis resistance 41.

Similarly, Y axis readings are accomplished by turning transistors Q2 and Q4 on to impress a voltage across the resistance 37. The X axis resistance 41 then serves as a mechanism to communicate the voltage at the point of contact with the Y resistance 37, this communication being through the terminal 49 which is connected to a non-inverting input of a second operational amplifier 107. An output 109 of the amplifier 107 is connected directly back to its inverting input.

The analog voltage in lines 105 and 109 are proportional to the X and Y coordinates, respectively, of the interconnection between the X and Y resistance sheets 41 and 37. These signals are applied one at a time to an analog-to-digital converter 111 through a multiplexer 113 (switch), followed by an isolation amplifier and a resistance-capacitance circuit, as shown. The multiplexer 113 receives in a line 115 from the CPU 91 a control signal telling it whether the signal in line 105 or that in 109 is to be passed on to the A/D converter 111. A signal in a line 117, also orginating from the CPU 91, tells the multiplexer 113 when to select one or the other signals. A control signal from the CPU 91 in the conductor 119 is connected to the A/D converter 111 to tell it when to start its conversion. Similarly, another control signal in line 121 tells the converter when to read the value of the conversion. A digitized version of the analog voltages in the lines 105 and 109 is then presented in time sequence to a system data bus 123 of the CPU 91. That system bus is connected through an appropriate buffer 125 to the system bus 23 of the main CPU 25 (shown in Figure 2).

The operation of the circuit of Figure 4 to obtain the X and Y coordinates of a particular connection between the X and Y resistances 41 and 37 will now be described with the aid of the timing diagram of Figure 5 and an operational flow chart of Figure 8. Figure 5 shows the time relationship of signals in seven different lines of Figure 4, those lines being identified on Figure 5. At an initial time to the PAD CHECK signal in line 95 goes high (from its 0 to its 1 state), as does the TPD control signal in the line 93. As can be seen from the logic circuit diagram of Figure 4, this condition causes the transistors Q1, Q2 and Q4 to be in their off (non-conductive) states while transistors Q3 and Q5 are in their on (conductive) states. This will provide a voltage to the non-inverting input of the amplifier 103 if the X ahd Y resistance sheets are touching anywhere. This results in a positive voltage in a line 127 from the output of the amplifier 103, communicating an ON PAD signal to the CPU 91. It is assumed for the purposes of this example that there is a closure of the two resistances 37 and 41 at some point, thus the ON PAD signal in curve (B) of Figure 5 follows the same form as the PAD CHECK signal of curve (A).

At time t1, the PAD CHECK signal from the CPU 91 is caused to return to its low or 0 state and the multiplexer 113 is connected to receive the X position analog signal in the line 105 by the appropriate signals in the lines 115 and 117 from the CPU 91. At this instant, the combination of a low PAD CHECK signal and the remaining high level of the TPD signal of Figure 5 (C) causes, it can be seen from the logic circuitry of Figure 4, transistors Q1 and Q3 to be turned on while the remaining transistors Q2, Q4 and Q5 are turned off. The voltage at the point of the resistance 41 that is being touched by the resistance 37 is thus communicated through the operational amplifier 103 and the mulitplexer 113 to the A/D 111 input. At time t2, the converter 111 is told to start its conversion and at time t3 it is told to read the value of the voltage in the line 105 onto the data bus 123 in digital form, the X coordinate of the touch.

Also at time t3, the control signal TPD goes low

and the multiplexer 113 is caused to switch to receive the Y position analog voltage in the line 109. The logic circuits of Figure 4, under those conditions, cause the transistors Q1 and Q3 to be turned off, while transistor Q5 remains off, and transistors Q2 and Q4 are turned on. The X resistance 41 is then used to communicate to the amplifier 107 the value of the voltage at the point on the Y resistance 37 where contact is made by the user pushing at a location on the surface of the touch pad. At time t4, the A/D converter 111 is told to start its conversion and at time t5 it is told to read the digital value of the Y position analog voltage in line 109 onto the data bus 123.

At this point, both the X and Y coordinates of a touch on the touch pad have been determined and are available for communication with the host CPU 25 (Figure 2) through the system bus 23. However, as shown in Figures 5 and 8, it is preferable to make a final check to make sure there is a closure between the resistances 37 and 41 at the end of the cycle. The cycle takes about 3 milliseconds, in this particular example, and it is preferable to accept the X and Y coordinate values only if the touch has occurred for at least that long. If it has not, it is unlikely that it is good data. Therefore, at time t6, the PAD CHECK signal and the TPD signal go back high and if the ON PAD signal also goes high as is shown in Figure 5, then it is known the detected touch of the touch pad was genuine and the X and Y values can be communicated for use of the system.

The form of the digital information developed by the CPU 91 and sent onto the system bus 23 is shown in Figure 7. Two bytes 131 and 133 are sent in immediate succession by the CPU 91. The data byte 133 contains a digital representation of the data while the immediately preceeding status byte 131 identifies the data. There are three types of data sent in this way. The first type is to indicate that one of the touch keys or buttons 65 through 79 of Figure 3 has been depressed and to identify which button it is. The CPU 91 compares the X and Y coordinate information developed as described above and compares it with the known X and Y limits of each of these push-button areas. It then provides in the status byte 131 a code indicating that some button area has been depressed and in the data byte 133 for this type of information the identity of the particular button being depressed.

If the CPU 91 determines that the X-Y coordinates received are in the cursor control area 63 of the touch pad of Figure 3, then the existence of cursor controlling information is indicated in the status byte 131 of Figure 7 and information as to the exact X/Y coordinates of the touch at a given cycle are included in the data byte 133. Since the X and Y coordinates are calculated every 30-40 milliseconds, in a particular implementation, movement of a finger across the touch pad area 63 will cause the CPU 91 to periodically send out new X and Y coordinate information as part of the byte 133. In one instant the byte 131 will indicate an X coordinate value is being reported by the byte 133, and in the next instant that the coordinate value is in the Y direction, and so forth. This information is then utilized by the host CPU 25 with standard cursor driving hardware or software to cause the cursor to move across the display 17 a distance and direction related to the movement of the finger across the area 63 of the touch pad. This is the second of the three types of data developed by the CPU 91 from the X-Y information so obtained from the touch pad.

In a preferred form of this second type of information, the CPU 91 communicates in the data byte 133 the differential movement, rather than the absolute X, Y position. That is, the distance of movement of the closure of the resistive sheets 37 and 41 from the location when the last reading was taken is reported. Further, it is desirable not to apply these differential signals directly to the cursor controlling hardware or software since this could cause the cursor to follow an erratic path should the user's finger not follow a smooth path. Therefore, the CPU 91 effects some smoothing of the successively acquired differential X and Y movement values by communicating onto the system bus 23 an average of a plurality of differential readings.

Figure 6 shows elements 135, 137, and 139 of a register internal to the CPU 91, as well as elements 141, 143 and 145 of another internal register. Each new differential X movement value is inserted into the first stage 135 of the first register while each new incremental Y movement value is inserted into the first stage 141 of the second register. In each successive measuring cycle, these values are moved through the registers from left to right and then discarded. The differential X movement value reported by the CPU 91 onto the system bus 23 through the data byte 133 is an average of the three values in the register elements 135, 137 and 139. Similarly, the incremental Y movement value is determined by averaging the last three incremental values stored in the registered elements 141, 143 and 145.

It is also desirable in most applications to provide a scaling feature of the cursor movement in response to finger movement in the X-Y area 63 of the touch pad. Thus, the host CPU 25, prior to applying the averaged incremental X and Y values to the standard cursor controlling software or hardware, manipulates these values by a magnitude proportional to the velocity of touch movement. A preferred technique is to mathematically square these values and then multiply that result by some constant (which can be unity). This results in the cursor moving further across the display screen 17 for a given distance of movement of the touch across the touch pad area 63 as the speed of movement increases. It can be seen that since each incremental X and Y value represents the touch movement during a fixed period of time, which is the cycle time of measuring the X and Y values, that the squaring of these differential values before applying them to the usual cursor controlling hardware or software will move the cursor a distance that depends upon the speed of the touch movement. If the user wants the cursor to go a short distance, the finger is moved slowly across the touch pad area 63. Rapid movement of the finger causes the cursor to go further for the same distance of finger movement.

Returning to the data format illustrated in Figure 7, the third and last type of information communicated in that way by the CPU 91 onto the system bus 23 is an indication as to when the X-Y touch pad area 63 has been tapped. That is, once the CPU 91 determines from the X and Y coordinates presented to it that a particular circuit closure between the resistive surfaces 37 and 41 is within the X-Y cursor control area 63, it then performs further investigations by viewing successive interrogations as to whether (1) the closure is greater than or less than a particular fixed time, usually in the neighborhood of a few hundred milliseconds, and (2) the closure has been moved more or less than a certain defined distance in the X direction or another certain defined distance in the Y direction during that particular fixed time interval. If the closure is for more than this particular fixed time or if the touch movement is greater than the certain defined X or Y distances, then the touch is interpreted as a cursor moving command and the second type of data word described above with respect to Figure 7 is communicated.

However, if the closure is less than the predetermined time and the touch movement is less than the certain defined X and Y distances, then a tap is detected and a different form of data according to Figure 7 is communicated to the system bus 23. The status byte 133 then indicates another touch key (push button); that is, the tap is treated simply as another push button area but a physically separate push button has not been required to generate it. The data byte 133 simply indicates by a unique code that it is a tap. Although the use of both the time and distance movement of the touch to discriminate a tap from a cursor movement signal are preferred for most applications, the use of just one factor or the other is satisfactory for some applications.

Thus the X-Y cursor movement area 63 serves the additional function of generating a push button like signal which is most advantageously utilized by the host CPU 25 as an execution signal of the type that normally follows the repositioning of the cursor on a computer display. Thus, the user need not take his or hier eyes off the screen to find another button to push to cause a desired execution at the location of the cursor but rather need only give a short tap to the X-Y area 63 where the finger already is positioned.

Another advantage of generating the tap signal in that manner is that it simplifies the electronic circuitry. The simplification in reduction of circuit components is extremely valuable in the case of a portable computer and, in other environments, provides a cost saving.

The computations described above as performed by the CPU 91 are illustrated in the state diagram of Figure 9 which illustrates the operation of the bulk of the controlling software of the CPU 91. The operations provided by the software in the portions marked as states 10 and 11 are illustrated by a circle 151 of Figure 9. In this state, the system is idle while going through its repetitive cycles of interrogating the touch pad to determine whether a closure between the resistive sheets 37 and 41 has occured. When a closure is detected by the existence of the ON PAD signal being returned, the system proceeds through a path 153 to states 20 and 21 indicated by a circle 155 if that closure is in the X-Y area 63 of the touch pad. If the closure is detected as part of the states 10 and 11 to be within one of the push button areas 65 through 79, then the system proceeds through a path 157 to state 30 indicated by a circle 159. When in the state 30, the system simply reports in a format described with respect to Figure 7 the particular push button area that has been depressed so long as the ON PAD signal remains high.

If in the state 155 as result of a closure in the X-Y cursor control area 63, a determination is made as to whether the closure has the characteristics of an executing tap or a cursor moving command, according to the criteria discussed above. If it is detected to be a tap, the system moves through a path 161 to states 50 and 51 indicated by a circle 163. On the other hand, if the closure is detected as an instruction to cause X-Y motion, the system moves through a path 165 to states 40 and 41 indicated in Figure 9 by a circle 167. When in the states 40 and 41, the system continues to report differential X and Y movement values through digital signals of the form discussed previously with respect to Figure 7.

When in states 40 and 41, a cycle of operation where the ON PAD signal has been detected to disappear causes movement along a path 169 to the states 50 and 51. When in these latter states, it will return to states 40 and 41 through a path 171 if the ON PAD signal remains absent for only less than a predetermined time (M counts). This thus provides the ability to accept "skating"; that is, an operator's finger when moving across the X-Y area 63 can be temporarily removed from the surface or too light to cause a closure for a short period of time and this will not cause the system to move into another state. However, as soon as it is detected that the ON PAD signal has been missing for more than predetermined time, then the system, operating in states 50 and 51, will return by a path 173 to the initial states 10 and 11.

Another feature of the software as illustrated in its state diagram of Figure 9 is the movement from states 50 and 51 through a path 175 to the state 30 when the ON PAD signal is restored in less than the predetermined time but as a result of the touch moving from the X-Y area 63 into one of the areas 65-79 (Figure 3).

Although the various aspects of the present invention have been described with respect to the preferred embodiment, it will be understood that the various aspects of the invention are entitled to protection within the full scope of the appended claims.

CLAIMS

1. An input device for a computer system, comprising: a touch-sensitive surface for producing a signal when the surface is touched to identify the location on the surface which has been touched; means for receiving a touch location signal for generating an area signal representing a given area of the sensitive surface when the given area is touched so that, in use, the given area acts as a

two-position switch for supplying instructions to the computer system; means for receiving a touch location signal for generating a position signal representative of a change in the location on the surface being touched when that location is in another area of the surface for controlling movement of an element displayed on a display means of the computer system.

2. A device according to claim 1, wherein the position signal generating means are arranged to generate a position signal only when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time.

3. A device according to claim 2, wherein means are provided for receiving a touch location signal representing a location in the other area and for generating a different signal to supply instructions to the computer system when the surface is touched for a time less than the predetermined time and/or the location touched on the surface changes by a distance less than the predetermined distance.

4. An input device for a computer, comprising: a touch sensitive surface for producing a signal when the surface is touched to identify the location on the surface which has been touched; means for receiving a touch location signal for generating a position signal representative of a change in the location on the surface being touched when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time; and means for receiving a touch location signal for generating a different signal to supply instructions to the computer system when the surface is touched for a time less than the predetermined time and/or the location touched changes by a distance less than the predetermined distance.

5. A device according to claim 3 or 4, wherein the different signal is a tap signal for instructing the computer system to carry out an instruction input thereto by a prior change in the location touched on the touch sensitive surface.

6. A device according to claim 4, wherein means are provided for receiving a touch location signal for generating an area signal representing a given area of the touch-sensitive surface when the given area is touched so that, in use, the given area acts as a two-position switch for supplying instructions to the computer system.

7. A device according to claim 1, 2, 3 or 6, wherein the touch-sensitive surface has a plurality of given areas and the area signal generating means is arranged to generate a respective area signal representing a given area when a location in that particular given area is touched to identify that particular given area so that, in use, each given area acts as a two-position switch for supplying instructions to the computer system.

8. A device according to claim 7, wherein the given areas are defined by means provided in conjunction with the touch-sensitive surface.

9. A device according to any preceding claim, wherein the position signal generating means comprises means for generating incremental distance movement signals per unit time for application to a cursor control system of the computer system.

10. A device according to claim 9, wherein the incremental distance signal generating means includes means for averaging a plurality of successive incremental distance readings before applying an incremental signal to the cursor control system, whereby potential erratic movement of touch across the surface is smoothed before the motion is imparted to the cursor.

11. A device according to claim 9 or 10, wherein the incremental distance signal generating means includes means for taking the square of each incremental value before applying it to said cursor control system, whereby the distance the cursor moves across the display means for a given distance of movement of touch across the surface depends upon the speed of such movement.

12. A device according to any preceding claim, wherein the touch sensitive surface comprises: first and second opposed sheets, each of the sheets having a given electrical resistivity per unit length on the surface thereof facing the other sheet, non-electrically conductive spacers being carried by the resistive surface of one of the sheets to normally hold the resistive surfaces apart but to allow the resistive surfaces to come into contact in response to the outside surface of one of the sheets being touched.

13. A device according to claim 12, when dependent on claim 8, wherein the area defining means comprises: a non-electrically conductive spacer positioned between the first and second sheets, the spacer having apertures formed completely therethrough in the locations of the plurality of given areas; and a visual pattern provided on the outside surface of the one sheet.

14. A device according to claim 12 or 13, wherein each of the sheets is quadrilateral and one pair of opposite edges of the resistive surface of one of the sheets is electrically connected in a manner to generate the touch location signal and the opposite pair of opposite edges of the other sheet are electrically connected in a manner to generate the touch location signal, whereby the resistive surface of one of the sheets measures a touch position in one direction and the resistive surface of the other of the sheets measures the touch position in another direction not parallel to the one direction.

15. An input device for a computer system substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

16. A computer system whenever incorporating an input device in accordance with any preceding claims.

17. A method of inputting data to a computer system, comprising: producing a signal when a touch-sensitive surface is touched identifying the location on the surface which has been touched; generating an area signal representing a given area of the touch-sensitive surface when the given area is touched so that the given area acts as a two-position

switch for supplying instructions to the computer system and for generating a position signal representative of a change in the location on the surface being touched when that location is on another area of the surface to control movement of an element displayed on a display means of the computer system.

18. A method according to claim 17, wherein a position signal is generated only when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time.

19. A method according to claim 18, wherein a different signal for supplying instructions to the computer system is generated when the other area of the surface is touched for a time less than the predetermined time and/or the location touched on the surface changes by a distance less than the predetermined distance.

20. A method of inputting data to a computer system, comprising: producing a signal when a touch-sensitive surface is touched identifying the location on the surface which has been touched; generating a position signal representative of a change in the location being touched when the surface is touched for a time greater than a predetermined time and/or when the location being touched changes by a distance greater than a predetermined distance in a predetermined time; and generating a different signal to supply instructions to the computer system when the surface is touched for a time less than the predetermined time and/or the location touched changes by a distance less than the predetermined distance.

21. A method according to claim 19 or 20, wherein the different signal is a tap signal for instructing the computer system to carry out an instruction input thereto by a prior change in the location touched on the touch sensitive surface.

22. A method of inputting data to a computer system substantially as

23. Any novel feature or combination of features disclosed herein.

Printed in the UK for HMSO, D8818935, 9/84, 7102.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.